

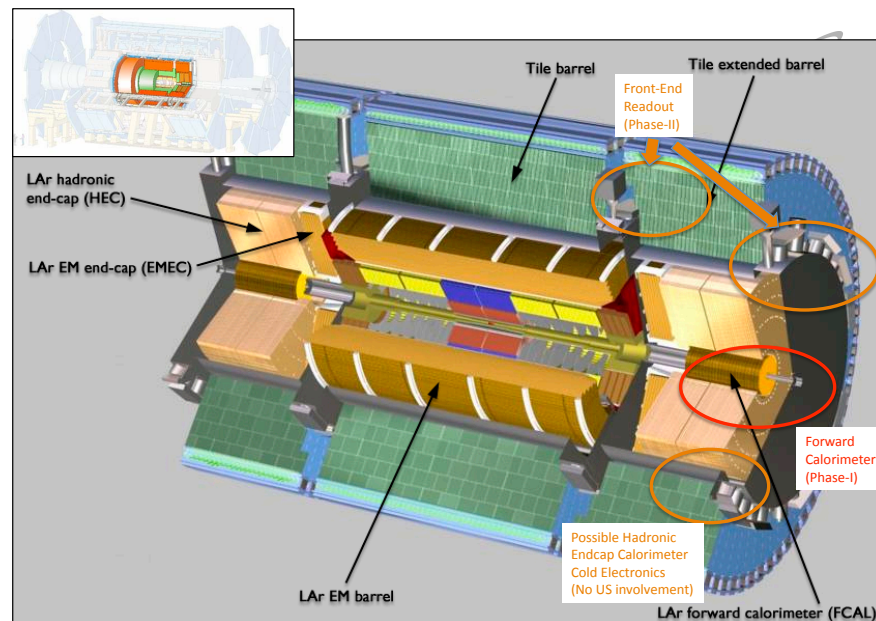


LAr FCAL Upgrade Plans

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Brookhaven National Laboratory

Outline

- The Atlas Calorimeter System
- General Atlas LAr Upgrade organization and plans (phase-I and II)
 - Readout Electronics
 - Cryogenic Front-End for the HadronicEndcap calorimeter
 - Engineering Studies
- FCAL issues @ sLHC upgrade
- Options for a new FCAL
- Toward an FCAL Upgrade Construction Project



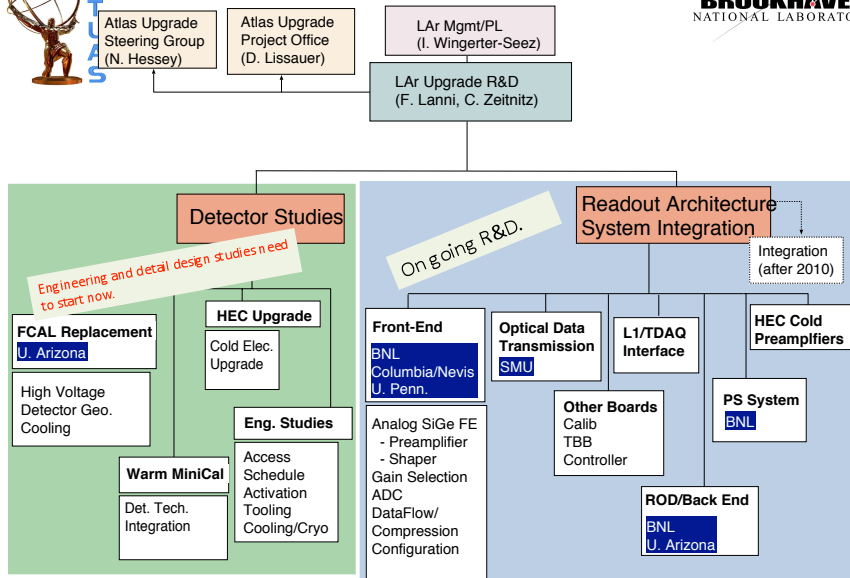
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2



LAr Upgrade Organization and Plans

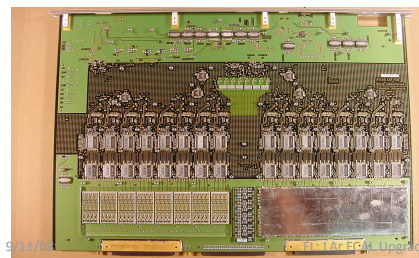


Readout Electronics Upgrade Plans

10 years @ 10^{34}

Radiation Type	Simulated Level	Safety Factors			Total Radiation Tolerance Criterion	3 -years @ sLHC
		Simulation	Low Dose Rate	Lot Variations		
Total Ionizing Dose	5 kRad	3.5	5	2	175 kRad	525 kRad
Neutron Fluence	$1.6 \times 10^{12} \text{ n/cm}^2$	5	1	2	$1.6 \times 10^{13} \text{ n/cm}^2$	$4.8 \times 10^{13} \text{ n/cm}^2$
Single Event Upsets	$7.7 \times 10^{11} \text{ h/cm}^2$	5	1	2	$7.7 \times 10^{12} \text{ h/cm}^2$	$2.3 \times 10^{13} \text{ h/cm}^2$

Phase-II upgrade needed because of radiation level issues of board components



- 1) Components can not be replaced as the technology will not be available.
- 2) Limited numbers of spares available.
- 3) Qualification for radiation tolerance is 10yrs at nominal luminosity.
- 4) Therefore replacement is required for sLHC..
- 5) May be replacement will be needed is failure rate is higher than expected?
- 6) Phase-II ...

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4

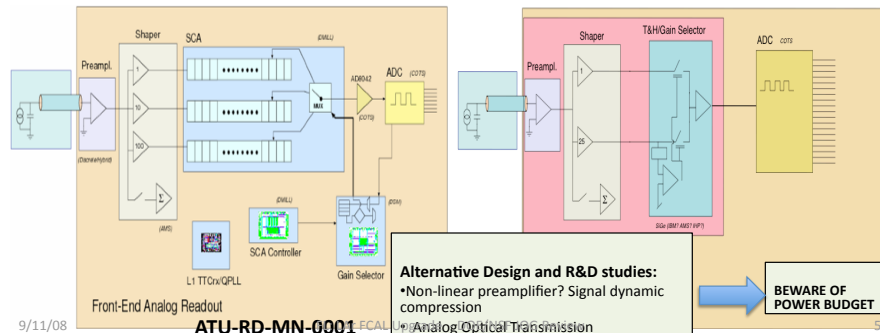
Readout Electronics Upgrade

Current Implementation:

- 3 Gain Settings (x1, x10, x100)
- Analog Pipeline (2.5 μ s)
- L1 receiver (100kHz max. trigger rate)
- Gain Selector mechanism and digitization upon receipt of the L1 signal

Baseline for sLHC:

- 2 Gain Settings?
- Pipeline off-detector. 40MSPS digitization
 - Data throughput: 100 Gbps/board
 - Radiation hardened FPGA and data lossless compression (100->30Gbps)?
- Analog T&H?
- How much integration on a single ASIC?



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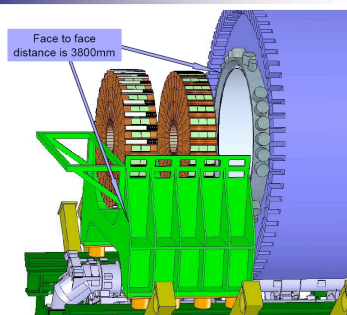
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5

Cryogenic Front-End for the Hadronic Endcap Calorimeter

- GaAs preamplifiers installed on detector
- Qualified for 10yrs operation at nominal luminosity
- R&D studies by MPI and German Universities to evaluate radiation tolerance above 10^{34} ...
- ...as well as alternative technologies (cryogenic SiGe processes)

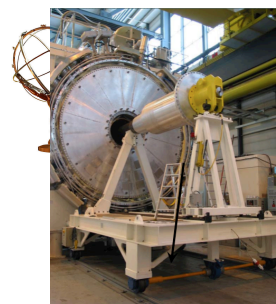
- Also (TRIUMF) tool design to access the calorimeter wheels for replacing the PC boards that house preamplifiers



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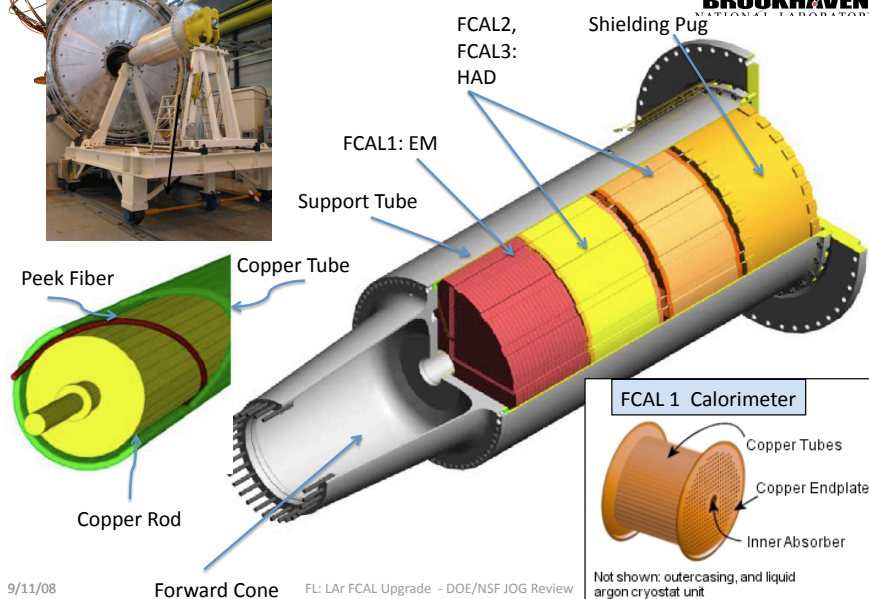
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6



(thanks to John Rutherford for his contributions)

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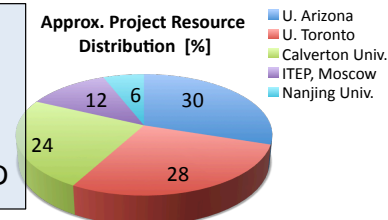
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The FCAL Project

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- The original construction project was a collaborative effort between 4 funding agencies.
- U.S Contribution: ~3.3M USD

Approx. Project Resource
Distribution [%]



US Contributions (U. of Arizona resp.):

- Development and design (...novel readout geometry developed for the SSC GEM detector and adopted by Atlas in 1993)
- Deliverables:
 - FCAL1 (e.m. modules)
 - HV distribution and summing boards
 - Cold cables
 - Share of responsibility of final assembly and installation @ CERN
 - Stewardship responsibility for optimal integration of the FCAL assembly into ATLAS, including calibration and software development
- J. Rutherford, U. of Arizona, was the LAr-FCAL project leader within the Atlas LAr collaboration during the whole construction phase.

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FCAL performance degradation

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- Detector performance will deteriorate at luminosities above the nominal 10^{34} .
- The main issues are:
 - Space charge effects arising from slowly drifting positive ion build-up
 - Heating by dE/dx of the FCAL modules with possible consequent boiling of Argon
 - Significant drop in the HV distribution that generates the drifting electric field in the detector elements.
- In at least the latter case there is no enough margin at 3×10^{34} so the FCAL performance may degrade significantly.
- Calculations are based on MonteCarlo simulation of minimum bias events. There are uncertainties associated to the different generators
 - Data availability by end 2008/mid 2009 will allow more accurate estimates
- A complete assessment of the performance degradation has just begun and it is being pursued vigorously

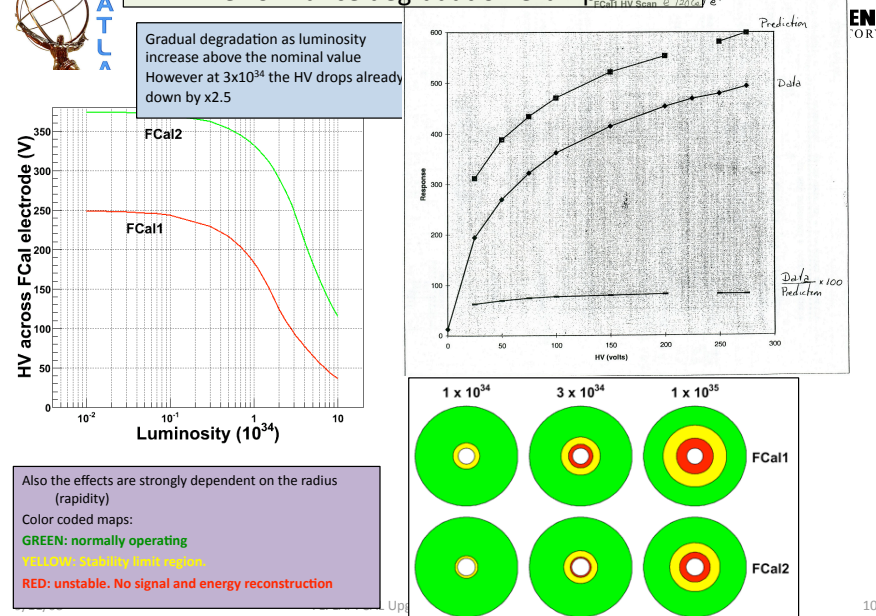
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9



Performance degradation example

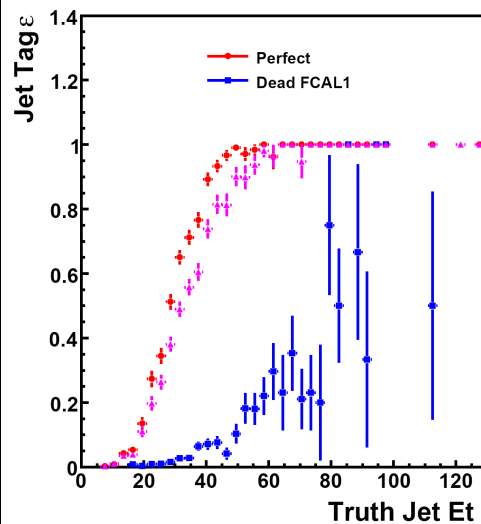


10



Physics Impact of a non functioning FCAL

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- Jet tagging in the forward region can be used to enhance S/B in some processes (e.g. events involving WW fusion)

- Preliminary simulations by C. Oram et al:
- <http://indico.cern.ch/conferenceDisplay.py?confid=24195>
- Dead FCAL 1 should be rejected as an option.

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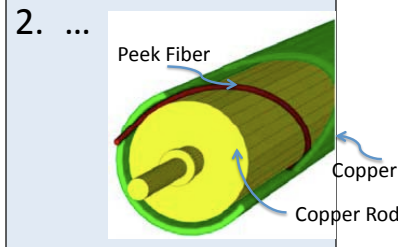
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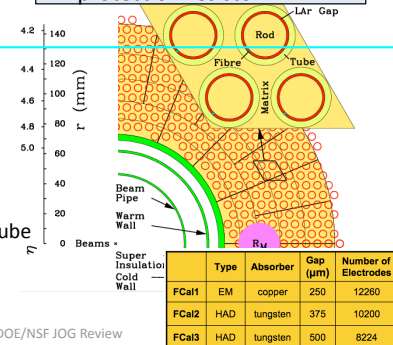
FCAL1 Upgrade Options

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- Two alternatives:
1. Design a newly re-optimized FCAL1



- Optimize tube geometry to eliminate space charge effects (smaller gaps)
- Engineer an inner cooling loop to intercept the heat and avoid risk of boiling
- Redesign HV bias distribution network and protection resistor.



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12

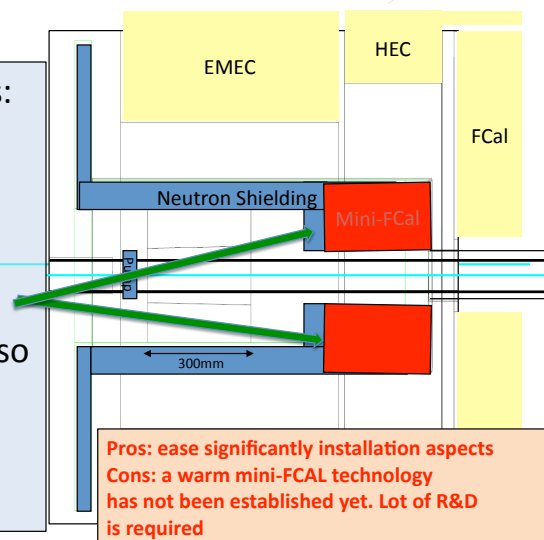


FCAL1 Upgrade Options

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Two alternatives:

1. Design a newly re-optimized FCAL1
2. Install a warm mini-FCAL in front of FCAL1 so that the latter becomes a tail catcher for EM showers



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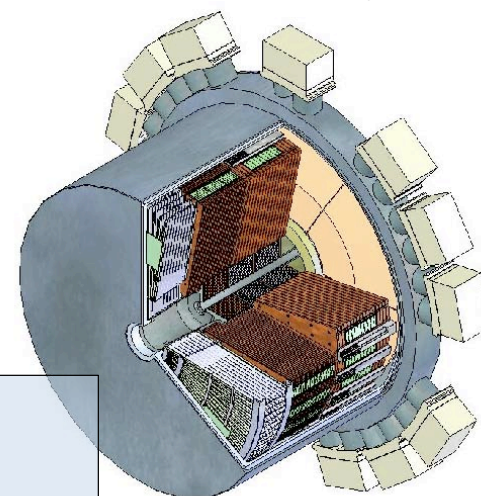
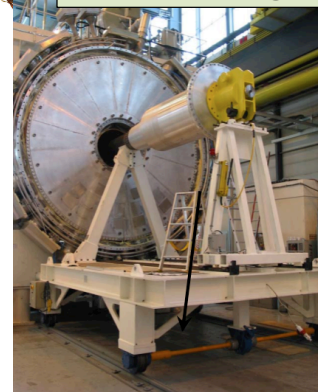
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13



FCAL Engineering Studies Needed!

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Severe Constraints for installation:

- Activation
- Limited Time
- Limited Access
- Tooling
- Conflicts with upgrade of other subsystems (ID and muon)

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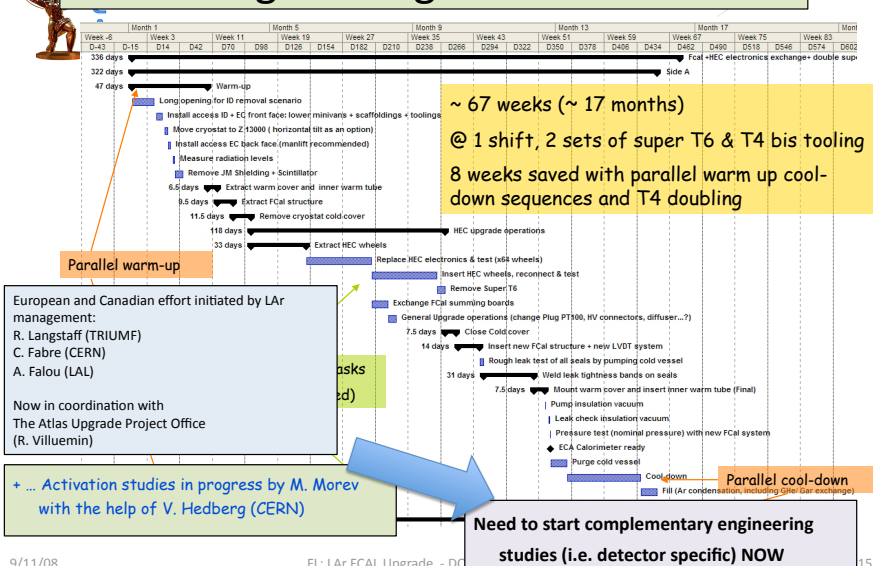
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14



FCAL Engineering Studies Needed!

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Atlas - LAr Strategy

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- The FCAL will not operate @ sLHC (Phase-II).
- The only possible upgrade is by the long shutdown (2016/2017)
- Need more studies to address criticality of the FCAL issues for Phase-I
 - Calculations are based on MC with significant variation between min. bias generators
 - Need to collect data (end of 2008/mid-late 2009)
- Scope of the project extends for several years
 - “Lessons” from the original construction project (design through installation onto the end-cap cryostat)
- Need to develop both options in parallel... **STARTING NOW...**
 - Detector R&D for the “warm”-option
 - Design and detailed engineering studies for a cold FCAL1 replacement as integral part of a construction project and of the decision making process
- Tradeoff between technology challenges vs. ease of installation/integration inside the Atlas detector
- Decision and ready to start production in 2011

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16



Summary: FCAL Upgrade Goals and US Deliverables



- Maintain leadership role in Atlas for the Forward Calorimetry
 - Developing tools and all preparatory engineering studies to be ready to launch replacement
 - Defining detailed design of an upgraded “cold” FCAL1 detector
 - **Request of a Phase-I construction project for a cold FCAL1 upgrade:**
 - Engineering resources and manpower for design of a newly optimized FCAL1 module, new services (cooling) and a new HV distribution scheme
- In case a “cold” FCAL upgrade will be decided (end 2011):
 - Assume direct responsibility in construction/assembly of the FCAL1
 - Share responsibility during assembly and installation phases at CERN
 - **Total: 51.1 FTE-yrs (2010-2018), 8.1M**
 - See Howard’s summary for detailed resource/manpower needs
- If the FCAL will be “warm” the US responsibilities and contributions have to be understood and clarified

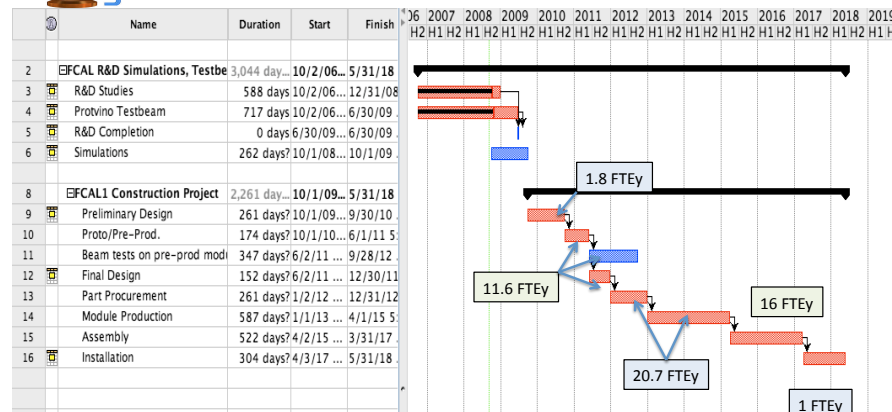
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17



FCAL Upgrade Construction Project



Schedule and Resources

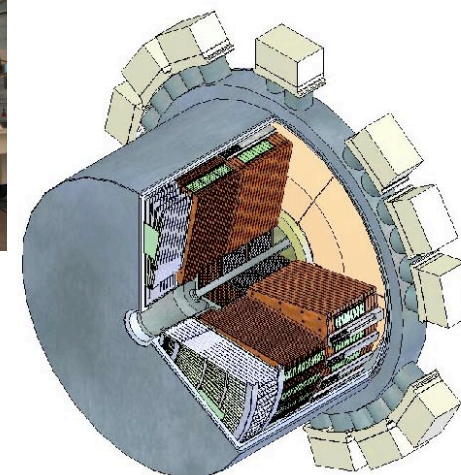
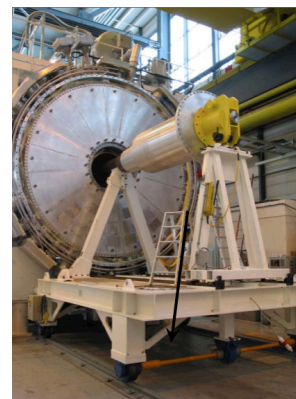
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18



Backup Slides

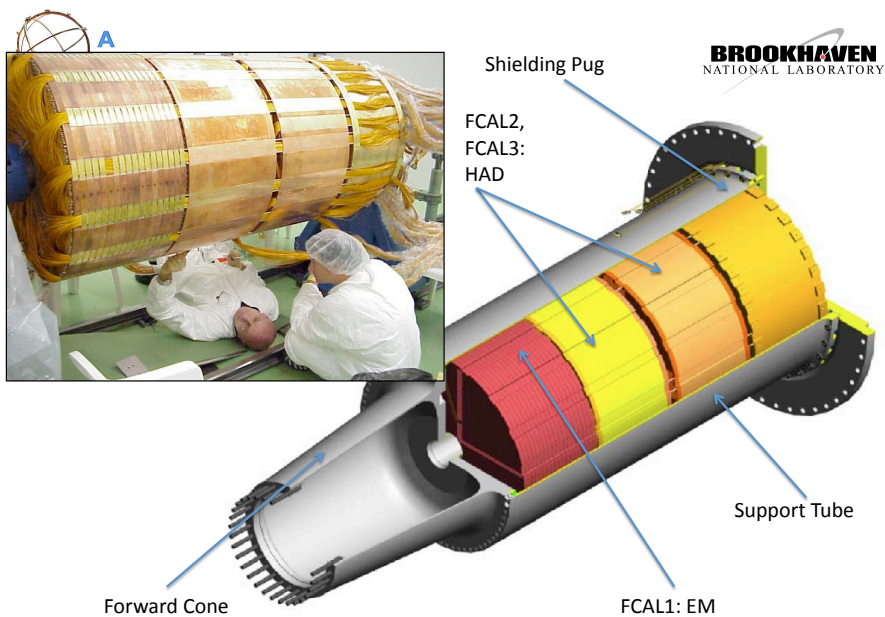


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19

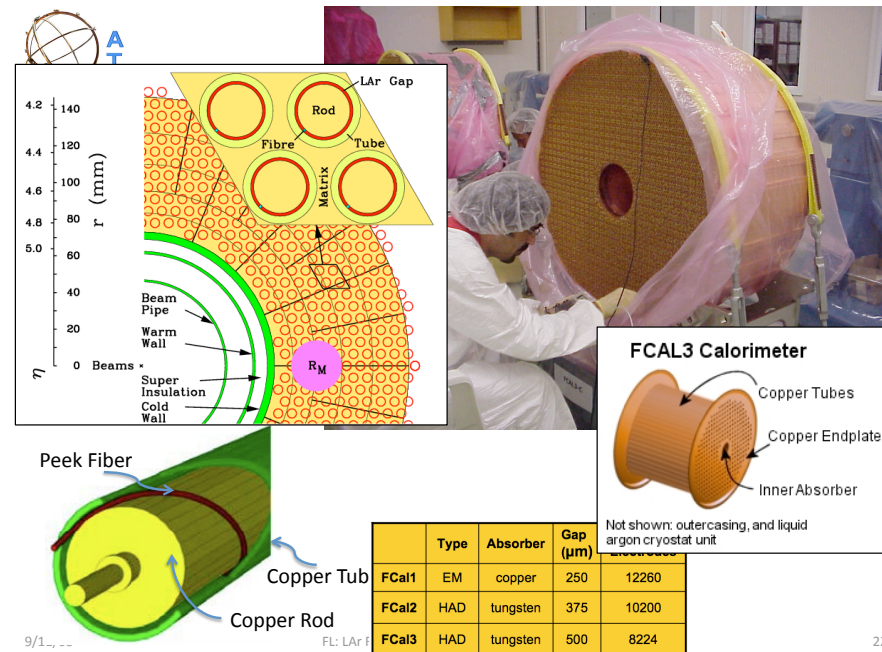
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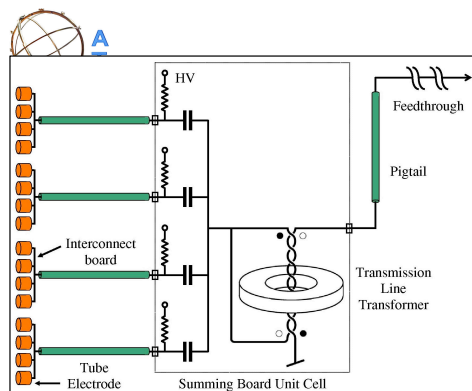
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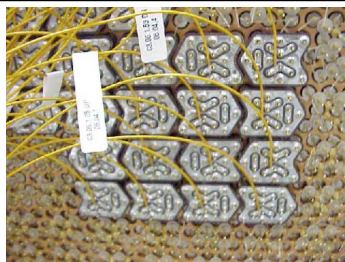
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22



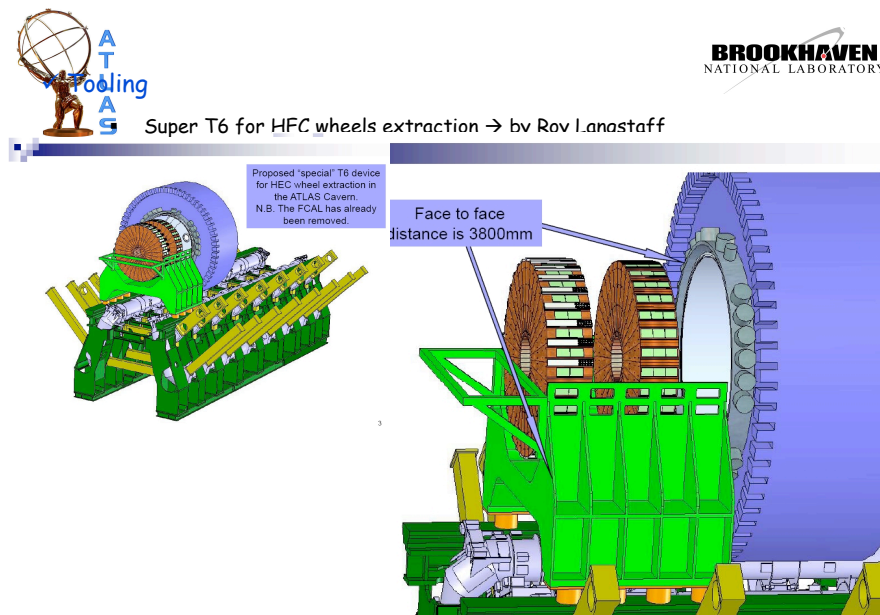
- Electrodes ganged together at module face:
 - 4, 6 and 9 for FCal1,2,3
- For most channels, 4 (adjacent) groups are summed on special SB PCBs in LAr
 - Provides adequate granularity
 - Reduced number of readout channels and FT penetrations
- Matching transformer and transmission line coupling to the "regular" Front-End Boards (preamp/shaper/SCA)



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23



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24